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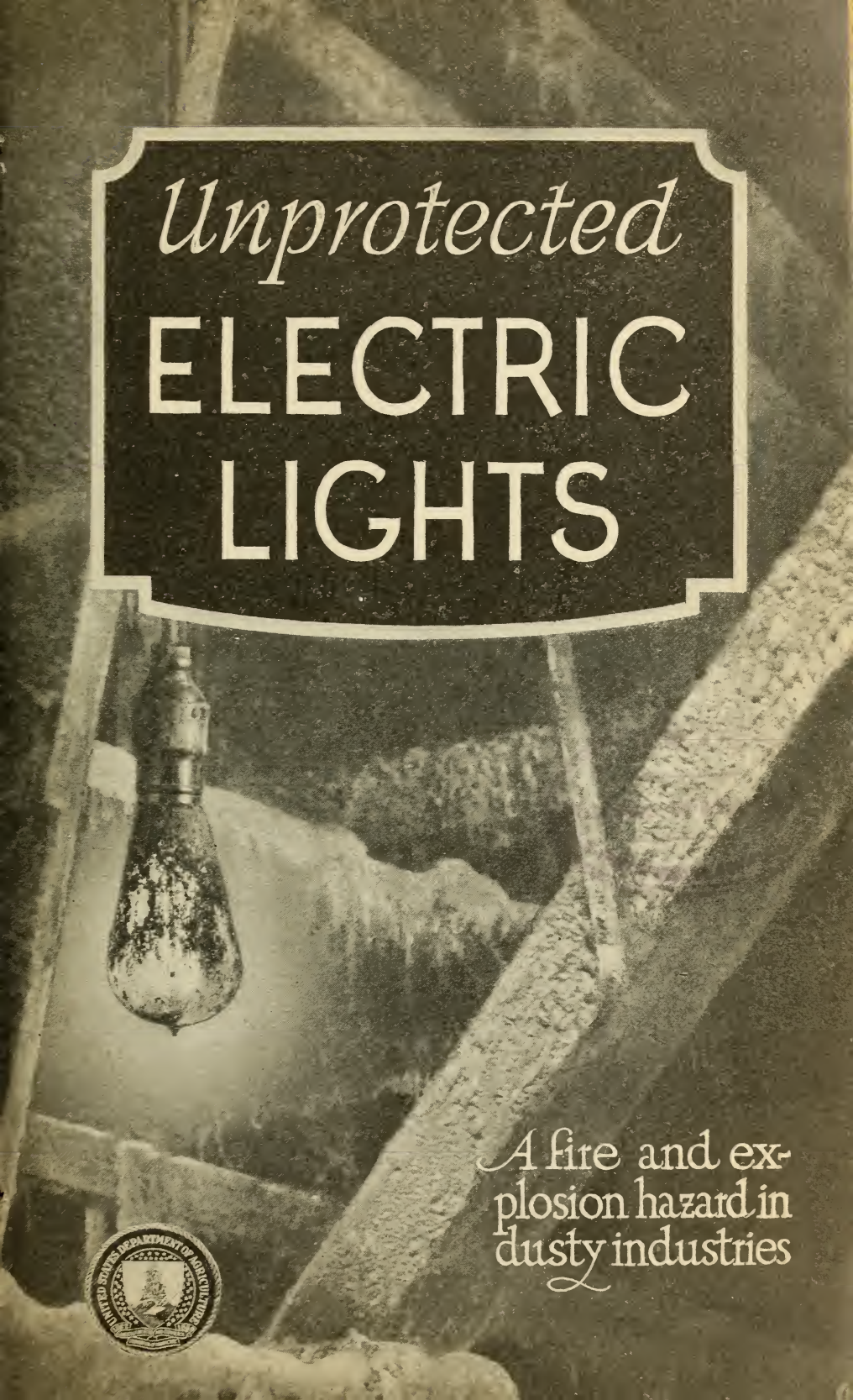
Unprotected ELECTRIC LIGHTS



A fire and explosion hazard in dusty industries

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Contribution from the Bureau of Chemistry

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A RECENTLY DEVELOPED DUST EXPLOSION AND FIRE HAZARD.

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FIRES DUE TO IMPROPER INSTALLATION AND INADEQUATE PROTECTION OF INCANDESCENT LAMPS.

Improper installation and inadequate protection of incandescent lamps constitute a fire and dust explosion hazard in dusty industries. In the investigation of many grain-dust explosions and fires in this country and Canada by the Bureau of Chemistry of the United States Department of Agriculture, the evidence obtained indicated that faulty electrical installations were responsible for the original ignition of the dust, although in some cases it was impossible to establish definitely the cause of the disaster. Sometimes the explosion occurred while an electric lamp on a cord was being lowered into a bin. Again, the fire which caused the explosion apparently originated on the floor of the plant in piles of dust directly below electric lamps suspended from the ceiling by drop cords.

It was known that fires could be readily started by burying an electric lamp in dust. During tests conducted at the Pittsburgh station of the Bureau of Mines a 32-candlepower electric lamp was placed in a box of fine coal dust. In less than 30 minutes the bulb had burst and the coal dust was found to be on fire. Following this experiment a 16-candlepower electric lamp was placed in a nail keg half filled with Pittsburgh coal dust. Eighteen minutes later small puffs of smoke issued from the keg and at the end of 32 minutes the dust smoked steadily, continuing to burn even after the lamp had been removed. As a result of these tests it was concluded that possibly a dust explosion could be started by the breaking of an incandescent lamp in a dust cloud or by the ignition of dust which had settled on the lamp.

During the dust explosion prevention campaign conducted by the United States Department of Agriculture and the United States Grain Corporation the men who visited the mills and elevators endeavored to obtain all possible information on this subject. About 20 cases were reported where the explosion or fire was supposed to have been started by the ignition of dust which had settled on the lamp or by the accidental breaking of an electric lamp in a dusty atmosphere.

According to the manager of a northwestern elevator, the dust which has collected on electric lamps often smolders and smokes and sometimes ignites and glows. He stated further that the dust coating on the globe had been known to take fire and drop to the floor, igniting dust there.

It is interesting also to note the experiences of an elevator company as reported in one of the journals devoted to fire protection. Three fires started in this plant within 5 feet of one another at intervals of one hour. As various theories concerning the origin of the fire were advanced, a detailed investigation was undertaken. It was found that the fires were caused by the collection of wheat dust on ordinary incandescent lamps. Apparently the dust was ignited by the heat of the globe and fell to the floor, where it set fire to dust. The trouble was remedied by the installation of double globes on the lamps.

PRELIMINARY EXPERIMENTAL WORK.

As many still thought it impossible to start an explosion in this way and it was difficult to obtain the actual proof of such cases reported to have occurred in industrial plants, it was decided to conduct experiments in which the conditions would be the same as those in factories where the hazard was supposed to exist. As the lamp manufacturers were equipped to conduct such experiments, the Bureau of Chemistry prepared an outline of the testing work to be done and arranged to have the investigations conducted in the laboratories of one of the large lamp companies.[1]

METHOD OF TESTING.

Previous tests made by the Bureau of Chemistry had proved that practically all combustible dusts when in suspension in air form an explosive mixture which can be ignited by an electric arc or static electricity. The question to be determined, then, was this: Will the exposed filament in a broken electric lamp remain hot long enough after the globe is broken to ignite the surrounding dust cloud?

To determine this, a series of tests were made in an explosion chamber constructed according to the diagram shown in figure 1. A socket to hold lamps of various sizes was placed in the bottom of the chamber and a rod, with trigger release, arranged to smash the lamp when a dust cloud had been formed in the chamber. The cloud was produced by blowing dust from small shelves along the side of the chamber. As this dust settled, the trigger was pulled, and the rod, springing back to its normal position, broke the globe.

[1] The tests were conducted in cooperation with the National Lamp Works of the General Electric Co., Cleveland, Ohio; Edison Lamp Works of the General Electric Co., Harrison, N. J.; and Westinghouse Lamp Co., Bloomfield, N. J. The lamp testing work referred to in this circular was carried on in the Nela Park laboratories of the National Lamp Works by C. L. Dows, assisted by H. G. Hills.

RESULTS OF TESTS.

Explosions were obtained with both vacuum and gas-filled lamps. The only exception was with the vacuum tungsten and carbon lamps of very low wattage. The failure to obtain an explosion with them

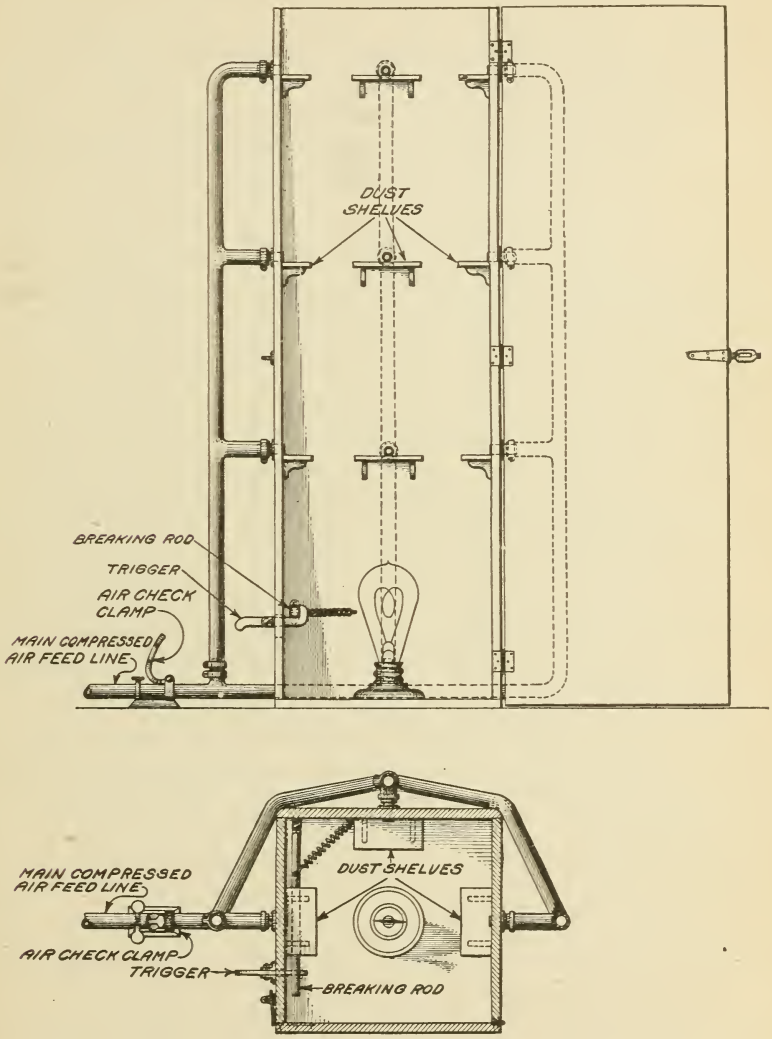

FIG. 1.—Explosion chamber.

was due probably to the character of the dust cloud and the manner in which the lamps were broken. Dust explosions and fires, therefore, can be caused by the breaking of an electric lamp in a dust cloud.

FURTHER EXPERIMENTAL WORK.

In the tests made to ascertain the danger due to the ignition of the dust on the globe more extensive investigations were necessary. Temperature readings of the various types of vacuum and gas-filled lamps on the market were compared with the ignition temperatures of the various dusts found in our industrial plants. Tables 1 and 2 give the temperature readings for representative types of lamps, as well as the smoking, melting, and ignition temperatures of various dusts. It will be noted that the temperature of the dust must be raised at least 150 Fahrenheit degrees above the maximum temperature of the bulb to cause ignition.

RESULTS.

In an especially constructed chamber in which a continuous dust cloud may be maintained it has been possible to start a fire on the larger gas-filled lamps with each of the first four samples listed in Table 1.

The ignition of these dusts is probably due to the fact that the very chaffy dusts collect on the globe, where they form a blanket which prevents radiation of the heat generated in the lamp and raises the temperature of the bulb to the ignition temperature of the dust. Some dusts seem to melt or congeal and form on the globe a crust which does not burn readily. Other dusts apparently do not form a blanket heavy enough to cause the temperature of the bulb to be raised to their ignition temperature. It is believed, however, that any combustible dust if allowed to collect on the lamp in sufficiently thick layers and remain long enough will ignite. Under ordinary conditions with the small lamps commonly used in our industrial plants and with free circulation of air around the globe, it is thought unlikely that a fire will be readily started in this way. It is, however, a hazard which should be guarded against.

TABLE 1.—*Smoking, melting, and ignition temperatures of carbonaceous dusts.*

Name of dust.	Smoking temperature.		Melting temperature.[1]		Ignition temperature.		Differences between smoking and ignition temperatures.	
	° F.	° C.	° F.	° C.	° F.	° C.	° F.	° C.
Sample 2 [2]	288	142	.....	.....	511	266	233	124
Sample 1 [3]	331	166	.....	.....	513	267	182	101
Sample 4 [4]	295	146	.....	.....	532	278	237	132
Sample 3 [5]	298	148	.....	.....	536	280	238	132
Cocoa	313	156	.....	.....	558	292	245	136
Graham flour	309	154	552	289	883	473	574	319
Cornstarch	284	140	545	285	891	477	607	337
White wheat flour	315	157	507	264	919	493	604	336
Corn meal	311	155	527	275	934	501	623	346

[1] Melting temperature is considered to be the point at which the dust becomes sticky or congeals.
[2] Approximately 22 per cent oats, 20 per cent durum, 40 per cent winter wheat, 10 per cent hard winter wheat, 10 per cent miscellaneous.
[3] Durum wheat dust.
[4] Approximately 40 per cent winter wheat, 35 per cent barley, 25 per cent oats.
[5] Approximately 60 per cent oats, 35 per cent winter wheat, 5 per cent rye.

TABLE 2.—*Bare lamp temperatures.*[1]

Type of lamp.	Maximum bulb temperature.		Temperature opposite filament.	
	° F.	° C.	° F.	° C.
Vacuum:				
50-watt	153	67	153	67
100-watt	152	67	152	67
150-watt	157	69	156	69
Gas-filled:				
75-watt	245	118	180	82
100-watt	259	126	178	81
150-watt	338	170	222	106
200-watt	327	164	222	106
300-watt	294	146	229	109

[1] Values are averages of several tests.

CONCLUSIONS FROM TABLES 1 AND 2.

Ignition temperatures extra chaffy dusts—511° to 558° F. (266° to 292° C.).
Ignition temperatures other dusts—883° to 934° F. (473° to 501° C.).
Dust therefore must be raised over 150 Fahrenheit degrees (83 centigrade degrees) to cause ignition.

METHODS OF FIRE AND EXPLOSION PREVENTION.

An investigation of the methods employed in the lighting of mills and grain elevators for the purpose of determining equipment which can be safely used, and the amount of illumination required, is now being made. At present it appears that many of the dangerous practices, such as the use of open wiring, drop cords, unprotected lights, etc., can be eliminated by modern lighting methods. The electric lamp is the safest source of light available, and the hazard involved in its use in dusty atmospheres can be eliminated by proper installation and protection.

All electric lamps in places where explosive dusts are present should be equipped with vapor-proof globes, protected by heavy guards to prevent breakage.

The straight-side vapor-proof globe which prevents the accumulation of dust on the lamp may be used to maintain a temperature below the smoking temperature of the dust, provided it is the proper size for the lamp it is designed to protect. The use of drop cords and the so-called extension lights or portable lamps on long cords is probably the most common objectionable practice and should be eliminated as far as possible.

The removal of fire and explosion hazards depends upon the cooperation of the mill and elevator operators. When properly used the incandescent lamp is the safest form of illumination known. The unprotected lamp, however, is a hazard that it would be well to eliminate from plants in which explosive dusts are produced.

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